Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

COAL RESERVES AND PRODUCTION FOR CANADA: 1981

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COAL RESEARCH LABORATORIES: CALGARY
DIVISION REPORT ERP/CRL 82-09(TR)

SELECTED CONVERSION FACTORS AND TERMINOLOGY

Multiply this		by this	to obtain	
British thermal unit (Btu)		1055.06	joule	J
Btu per pound		2.326	kilojoule per kilogram	kJ/kg
cubic yard		0.764 555	cubic metre	m^3
cubic yards per ton		0.842 78	cubic metres per tonne	m^3/t
foot		0.3048	metre	m
joule	J	0.000 947 8	Btu	
kilojoule per kilogram	kJ/kg	0.429 923	Btu per pound	
kilometre	km	0.621 371	mile	
litre per second	L/s	13.1982	gallon per minute	
megajoule per kilogram	Mj/kg	429.923	Btu per pound	
metre	m	3.280 84	foot	
mile		1.609 344	kilometre	km
short ton per acre foot		7.354 67	tonne per hectare metre	t/ham
ton (long)		1.016 046 908 8	tonne	t
ton (short)		0.097 184 74	tonne	t
tonne		0.984 206 5	long ton	
tonne		1.102 311	short ton	

SI PREFIXES

Multiplying Factor	Prefix	Symbol
1 000 000 000 000 000 000 = 10^{18}	exa	E
1 000 000 000 000 000 = 10^{15}	peta	P
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 19^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecto	h
10 = 10^{1}	deca	da
0.1 = 10^{-1}	deci	d
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	μ
0.000 000 001 = 10^{-9}	nano	n

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SUMMARY

The last assessment by Energy, Mines and Resources (EMR) of Canada's coal resources and reserves was presented in Report ER 79-9, "Coal Resources and Reserves of Canada" by H.U. Bielenstein, L.P. Chrismas, B.A. Latour and T.E. Tibbetts, dated December 1979. In that report CANMET contributed data on coal reserve tonnages and coal quality available up to January 1, 1978.

This report updates the data on coal reserve tonnages and coal quality to December 31, 1981. There is no attempt to update resource tonnages in this report. The coal resource update is being undertaken by the Geological Survey of Canada.

Almost all of Nova Scotia's coal reserves are located in the Sydney Coalfield. The Donkin-Morien Project of the Cape Breton Development Corporation has provided a major addition to Nova Scotia's recoverable coal reserves i.e. coal which can be recovered as run-of-mine coal. A significant drop has occurred in New Brunswick's coal reserves because of a more stringent definition of what constitutes a coal reserve. There are prospects of developing additional reserves from the existing resource base in the Minto Coalfield.

Feasibility studies of the Onakawana lignite deposit in Ontario, south of James Bay, have postponed further development of this low rank coal for electric power generation.

New data on the extensive lignite deposits in Southern Saskatchewan are not available, so the recoverable coal reserves for Saskatchewan are those presented in Report ER 79-9, less production from 1978 to 1981, inclusive.

Because of the more stringent definition of what constitutes a recoverable coal reserve the tonnage figures for Alberta Plains coal have dropped significantly. It must be emphasized this in no way signals a decrease in Alberta's coal resource base, or its potential for further development. For reasons explained in both Report ER 79-9 and in this report, coal resource and reserve terms adopted by Alberta's Energy Resources Conservation Board and those used by EMR are quite different and not easily comparable.

Major coal developments since 1978, in the Peace River, Elk Valley, Crowsnest and Hat Creek Coalfields in British Columbia have placed tonnages in these deposits into the coal reserve category, thereby adding significantly

to recoverable coal tonnages in that province.

The following table summarizes the changes in recoverable coal quantities presented in Report ER 79-9 and in this report:

Province/ Region	Recoverable coal reserves ($\times 10^6$t)			Remarks
	Report ER 79-9	This report	Difference	
Nova Scotia	89	455	+356	Donkin-Morien Project has added 212×10^6 tonnes recoverable coal.
New Brunswick	33	5.7	-27.3	more stringent definition of coal reserves; resource base unchanged.
Ontario	NA	0	-	
Saskatchewan	1 720	1 697	-23	no new data; coal produced from 1978-81 deducted from previous total.
Alberta Plains	2 182	929	-1 253	more stringent definition of reserves; resource base actually increased per ERCB Report 82-31(ref.16).
Alberta Foothills	239	240	+1	
Alberta Mountains	291	259	-32	more stringent definition of reserves; resource base unchanged
British Columbia				
bituminous	955	2 098	+1 143	major projects added
lignitic	397	566	+169	more coal considered recoverabl from Hat Creek Project
Canada total: lig	2 117	2 263	+146	no new data on Saskatchewan lignite; increase in Hat Creek reserves.
sub	2 182	929	-1 253	more stringent definition of reserves; resource base increased (per ref.16).
bit	1 607	3 046	+1 439	major new developments in B.C. and N.S.
BITUMINOUS METALLURGICAL, included in BITUMINOUS above				
Nova Scotia	69	133	+64	
Alberta	290	259	-31	
British Columbia	904	1 643	+739	
Total metallurgical	1 263	2 035	+772	

1. INTRODUCTION

1.1 PURPOSE OF REPORT AND BACKGROUND

This report is linked to two previous assessments of Canada's coal resources and reserves by Energy, Mines and Resources (EMR), namely Report EP 77-5 entitled "1976 Assessment of Canada's Coal Resources and Reserves"(1) and Report ER 79-9 "Coal Resources and Reserves of Canada" (December, 1979) (2). These two departmental reports included contributions from various groups in EMR. The Office of the Coal Advisor, Energy Policy Sector provided data on coal production and coordinated the reports' preparation and distribution. The Geological Survey of Canada provided data and information on coal resources. CANMET contributed data and information on coal reserves plus coal quality. The reports have been widely circulated and are frequently cited as authoritative assessments of Canada's coal resources and reserves by organizations which include the National Energy Board and the Coal Association of Canada.

This CANMET report likewise focuses on coal reserves along with coal quality data for 1981. The basic difference between this reserve assessment and that given in Report ER 79-9 is that reserve quantities have been identified with a more strict EMR definition of what constitutes a coal reserve - which is in line with EMR's assessment of the nation's uranium, precious metal and base metal reserves.

Over the past three years production feasibility studies required by provincial government regulatory agencies have placed tonnages in a number of large deposits into the reserves category. Notable among these are the Hat Creek, Quintette, Bullmoose and Sukunka deposits in British Columbia, the Obed Marsh property in Alberta and the Donkin-Morien project in Nova Scotia. These and other deposits which meet EMR's reserve definition requirements have now been included in the reserve quantities given, with the effect that there have been major additions to reserves in British Columbia and Nova Scotia. Because feasibility studies have not been done and publicly announced on the greatest part of Alberta's massive coal resources, this coal is still not considered as a reserve, except for what is within "mine permit areas" and coal developments approved by Alberta's Energy Resources Conservation Board.

In Report ER 79-9 the reserve terms used to describe the progressive conversion of a coal deposit into a saleable product are:

mineable coal	(Level 1)
recoverable coal	(Level 2)
saleable coal	(Level 3)

In this report the term "mineable coal" has been avoided because of the tendency to confuse it with "recoverable coal". It has been replaced with the term COAL IN MINEABLE SEAMS. Reserve terminology is discussed more fully in Section 2.1 and the terms are defined in Appendix "B". As well, resource definitions for "measured coal" and "indicated coal" are given in Appendix "A", in terms of distances between points of observation for major physiographic regions in Canada.

Units of measurement presented in this report are given in the International System of Units (SI) as approved for official use by the Canadian Standards Association and Metric Commission Canada. These units have been adopted by The Mining Association of Canada and The Coal Association of Canada to promote correct and uniform use of SI in mining, milling, smelting and refining operations in Canada. These two associations have published "Metric Practice Guide for the Canadian Mining and Metallurgical Industries", 1978 (3) from which most of the prefixes, terminology and conversion factors listed on the inside cover page were selected.

1.2 DEPARTMENT'S CURRENT OBJECTIVES

In an address to the Canadian Conference on Coal in Regina on September 21, 1981 the Minister of State for Mines made two references to the adequacy of Canada's coal resource base, namely:

.... "to allow exports on a virtually unrestricted basis implies that we are certain our resource base is sufficient to support both these exports and the foreseeable needs of our domestic market." ....

and

.... "Canadians will want to be reassured that as our (coal) exports grow, the resource base is in fact adequate. For this reason, my department, in cooperation with the provinces, will re-activate its efforts to determine the quantity and quality of coal available with increasing emphasis on probable replacement costs, the effects of environmental restrictions on both production and utilization related especially to sulphur content, and other similar concerns." ....

As well the Minister of State for Mines mentioned that Canadians need to be reassured about the ownership situation in the coal industry. However, this issue is outside CANMET's mandate and will not be discussed in this report.

In the Discussion Paper on Coal published in September, 1980 as Report EP 80-1E under the authority of the Minister of Energy, Mines and Resources, the comment was made on p.11 .... "we want to avoid transferring the advantages of low cost energy to other nations now, while reserving only the more expensive coals for domestic consumption later." ....

In addition to the above policy comments by EMR officials there were guidelines published by the Minister of the Environment on April 25, 1981 (4) which are aimed at diminishing the emissions of air-polluting discharges to the atmosphere from new electric power generating units. Entitled "Thermal Power Generation Emissions - National Guidelines for New Stationary Sources" the guidelines are intended to diminish problems associated with "acid rain" by recommending to provincial government air pollution control agencies that the following concentrations of pollutants should not be exceeded for certain specified time periods when burning fossil fuels:

(i) for Nitrogen Oxides expressed as NO_2:
258 nanograms per joule (258 ng/J) of heat input which is equivalent to 0.6 pounds per million British thermal units (0.6 $lb/10^6$ Btu) of heat input, when fired with solid fossil fuel such as coal.

(ii) for Sulphur Dioxide:
Generating units emitting more than 258 ng/J (0.6 $lb/10^6$ Btu) of heat input, when uncontrolled:

(a) those units emitting between 258 ng/J and 2580 ng/J (0.6 $lb/10^6$ Btu and 6.0 $lb/10^6$ Btu respectively) should be controlled such that the final emission does not exceed 258 ng/J (0.6 $lb/10^6$ Btu).

(b) units emitting more than 2580 ng/J (6.0 $lb/10^6$ Btu) should be controlled so that a minimum of 90% of the uncontrolled emission is captured before release to the atmosphere.

(iii) for Particular Matter: 43 ng/J (0.1 $lb/10^6$ Btu) of heat input.

The above emission guidelines impact on any assessment of Canada's recoverable coal reserves which might be utilized for domestic electric power generation.

Several demand forecasts have been made for Canadian coal over the past several years. The most recent of these was published by the National Energy Board (NEB) (5). Tables 1 and 2 are reproduced from this NEB report and compare forecasts by various corporations and agencies in terms of heat value (petajoules) and percent increase per annum. There is no question about coal demand increasing. The issue is by how much.

Table 1 - Demand for coal - Canada
Comparison of forecasts (petajoules)

	1980	1985	1990	1995	2000
Canadian Petroleum Association	915	-	1 396	-	-
The Coal Association of Canada*	1 027	1 198	1 709	2 414	3 153
Gulf Canada Ltd.*	856	1 230	1 494	1 922	2 415
Imperial Oil Ltd.	993	1 151	1 409	1 696	2 129
Norcen Energy Resources Ltd.*	980	1 143	1 284	1 455	1 643
Petro Canada*	871	1 124	1 442	1 729	2 060
Shell Canada Ltd.*	891	979	1 083	1 164	1 268
Texaco Canada Inc.	988	1 161	1 329	1 534	1 767
National Energy Board	1 019	1 145	1 337	1 711	2 051

*Supplemental forecast

Table 2 - Demand for coal - Canada (growth rates)
Comparison of forecasts (percent per annum)

	1980-1990	1990-2000	1980-2000
Canadian Petroleum Association	4.3	-	-
The Coal Association of Canada*	5.2	6.3	5.8
Gulf Canada Ltd.*	5.7	4.9	5.3
Imperial Oil Ltd.	3.5	4.2	3.9
Norcen Energy Resources Ltd.*	2.8	2.5	2.6
Petro Canada*	5.1	3.6	4.4
Shell Canada Ltd.*	2.0	1.6	1.8
Texaco Canada Inc.	3.0	2.9	2.9
National Energy Board	2.8	4.4	3.6

*Supplemental forecast

The implication of the above policy statements and demand forecasts is that policy makers need some answers to the general question: how much coal, of what quality, can be recovered where in Canada, and at what relative cost. This report represents part of CANMET's contribution of technical information and data needed to answer this complex question.

1.3 CANMET'S COAL RESERVES AND PRODUCTION PROJECT

The project's objective is to assess both the recoverable reserves of coal in Canada and production and to publish the results biennially, beginning with the assessment for the calendar year 1981. There were two project elements for the fiscal year 1981-82, summarized as follows:

Project element	Objective	Person-Years (1981-1982)
43 01 02.01	Compile data on operational coal reserves, representative qualities, limiting criteria, and likely mining methods for each coalfield or coal region.	1.25 (Mining Research Labs. Calgary)
43 01 02.02	Using the G.S.C.'s SASCO file, develop methodology to derive surface mineable coal for Southern Saskatchewan	1.0 (Mining Research Labs. Ottawa)

The likely clients for this work, as reported herein, have been identified as:

- EMR and provincial energy policy groups
- Coal development and mining companies
- Trade officials
- The Coal Association of Canada.

The report stemming from work on the SASCO file is "Methodological Development for a Reserve Inventory of Coal in Southern Saskatchewan", Division Report ERP/MRL 82-38(TR) by R. Sabourin and R. Boyle, March, 1982.

1.4 SOURCES OF DATA, INFORMATION AND ACKNOWLEDGEMENTS

It may be recalled that data on Canada's coal reserves, as presented in Report ER 79-9(2), were based on questionnaires sent to operating mining companies and coal-lease holders and on published information to January 1, 1978. In the four years since, there has been a surge of new coal developments. Besides major expansions to several existing mine operations, two new mines have come on stream, ten are in the construction-development stage and several more are in the planning-development stage, as detailed in Section 1.5 and Appendix "C". The past four years also saw the closure of two long-established underground coal operations in Alberta because coal remaining in these properties was no longer considered by the mine operators to be economically recoverable. The underground operations of Coleman Collieries Ltd. in the Crowsnest Pass area closed in March, 1979 and operations at the Canmore Mines Ltd. located at the eastern entrance to Banff National Park closed in July 1979. The Canmore Mines first produced coal in 1888, primarily to fuel the steam engines hauling along the newly-constructed CPR trans-mountain railway line.

The approval of coal projects in Alberta and British Columbia follows well-defined procedures (6,7) which have resulted in some public disclosure of data on coal reserve quantities, limiting criteria, coal quality, mining plans, environmental impact assessments etc. In this regard the writer wishes to acknowledge assistance in accessing public documents held in the Coal Department of Alberta's Energy Resources Conservation Board and the Mineral Resources Branch of B.C.'s Ministry of Energy, Mines and Petroleum Resources. As well, the author wishes to thank the managers of various coal mining operations and developments across Canada who, without exception, have permitted field trips to their mine properties.

The cooperation of the Statistics Section of Energy Policy Analysis in EMR and of the Energy and Minerals Section of Economic Statistics in Statistics Canada in providing data on coal production is acknowledged.

The geostatistical work described in project element 430102.02 was based on the Geological Survey of Canada's computerized file of borehole and other data resulting from a joint federal/provincial study of the lignite resources and reserves in Southern Saskatchewan. The SASCO file was one of several outputs from this study (8) by the GSC, CANMET and the Saskatchewan Research Council. The GSC's cooperation in making this file available is acknowledged.

As well, the writer is grateful to H.G. Naidu who joined CANMET's staff in Calgary in May, 1982 for his compilation of coal reserve quantities as tabulated in Section 2 of this report. The acquisition of these data and their reconciliation, where significant differences occur, are no easy tasks.

1.5 OPERATING COAL MINES AND PROJECTS UNDER DEVELOPMENT AS OF DECEMBER 31/81

Coal operations range from established producers in historical coalfields to likely prospects in entirely new regions. Appendix "C" presents this information in three groupings, by coalfield, namely:

Part I: Operating Coal Mines

Part II: Coal Projects in the Construction-Development Stage

Part III: Coal Projects in the Planning-Development Stage

What constitutes a project in the planning-development stage can be a matter of opinion. For projects in Alberta and British Columbia, the provincial government's assessment procedure provides a useful measure of the degree to which individual projects have advanced. The step-by-step assessment of projects moving from exploration prospects to operating coal mines is detailed in references (6) and (7) for Alberta and British Columbia respectively.

2. COAL RESERVES

2.1 RESERVE TERMINOLOGY

Reserve and resource terminology continues to be a source of misunderstanding simply because the words take on different meanings for different persons. This report, like its predecessors (1,2) is an early attempt at providing some answers to the question of national coal supply as expressed in the deceptively simple phrase ...."how much coal, of what quality, can be recovered where and when in Canada, and at what relative cost" .... Before defining the coal reserve terms used in this report it may be worthwhile to examine the two facets or dimensions implicit in the word "reserve", namely,

- geological assurance of existence
- technical/economic feasibility of exploitation

For a judgment of feasibility of exploitation, it is also necessary to consider production rate/timing, which can be viewed as the link between reserves and supply.

Readers are referred to a recent report by Zwartendyk (9) on the pitfalls which commonly accompany the mental exercise of converting an in-place mineral deposit to a saleable mineral commodity which then represents part of supply. The various dimensions to this exercise, as they apply to this coal reserve assessment, are discussed next.

The descriptor MEASURED is preferred within EMR to designate those coal resources whose geological existence is most assured. Ideally, this assurance would be quantified and expressed as a kriging variance or as a percentage error which in turn would convert to a range for estimated tonnages. However, this geostatistical approach requires data bases and methodology which, with the exception of the SASCO file (8) and a few smaller data bases, are still under development. The alternative is to link terms such as MEASURED and INDICATED to certain maximum distances between reference points (usually boreholes) as was done in Report ER 79-9, for each of the major physiographic regions in Canada where coal is being mined. These distances are given to Appendix "A".

This report purposely omits any references to coal whose confidence level is at the low end of the descriptor scale, namely "inferred" or "speculative", because such coal does not enter the foreseeable coal supply

picture. Consideration of such resources would detract from one of the objectives for this report which is to identify coal already discovered in terms which are understood, rather than speculate on coal deposits which have yet to be discovered.

Once a coal deposit's tonnage is reasonably well assured the next dimension to be considered is the technical/economic feasibility of its exploitation. The usual way of assessing this facet is the production feasibility study which includes the identification of the specific mining method and production rate, a flow sheet for the coal preparation plant (assuming the coal will be beneficiated), saleable coal quality characteristics, the environmental impact assessment, manpower needs, and needs for power, water, surface plant, transportation, housing, etc. Taxes and royalties must likewise be considered in this feasibility study. The subject of project feasibility would be incomplete without mentioning one important assumption about its future, namely the assumption that markets at current prices will exist for all the saleable product. This can be restated as an assumption that prices will generally remain above costs for the time period the coal deposit is being considered for production.

Production feasibility studies are required by provincial government regulatory agencies in Alberta and British Columbia before approval-in-principal is given either to new coal projects or to major expansions of existing operations. These feasibility reports, or reports produced by the regulatory agency in support of its decisions, become public documents, when approved, and are therefore an important source of data on coal reserve quantities, limiting criteria, representative coal qualities, mining methods, etc. Established mine operators usually undertake their own feasibility studies to derive coal reserves for the continuing operation of their mines but these data are not usually available to the public.

Without the production feasbility study it is easy to stray into that grey area, also referred to as the argument zone, into which national reserve assessment reports tend to disappear, only to reappear later, with reserve quantities reduced by an order of magnitude. Figure 1 illustrates the point that, in spite of starting from the same base, different methods produce quite different reserve quantities. If the objective is to answer questions of foreseeable coal supply then one must go beyond the application of general factors such as maximum depth, minimum thickness etc. to coal resources located on a regional basis, and thereby derive coal reserves.

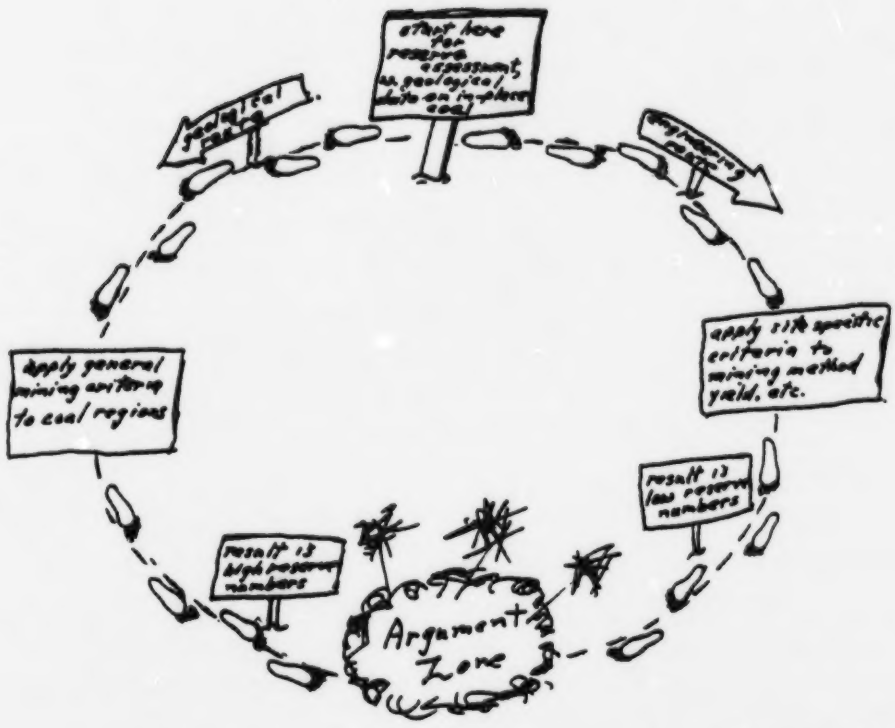

apply general mining criteria to coal regions
apply site specific criteria to mining method yield, etc.
result is low reserve numbers
result is high reserve numbers
Argument Zone

Fig. 1 - Geological vs engineering routes to reserve assessment

Other important consideration are the rate and timing of production. Policy makers, coal producers, coal buyers and coal transporters are becoming increasingly concerned not only with the "how much" but also the "when" aspects of the coal supply question, especially in times of high interest and inflation rates. Feasibility studies on Canadian bituminous coals destined for the export or domestic market normally cover a time span of 15 years, which is the usual time span for long-term supply contracts. Lower rank coal deposits destined for local power generation plants are evaluated for a 30 year time span as this is the usual time span considered reasonable to write off the capital cost of a power generating plant.

Turning now to coal reserve terminology, this report introduces one change from the terms used in Report ER 79-9. Ther term "mineable coal" used previously has been replaced with COAL IN MINERABLE SEAMS, because the former term tends to be confused with RECOVERABLE COAL. The term SALEABLE COAL is

clear and broadly accepted. Thus, the reserve terms used to describe the mental exercise of converting a coal deposit into a saleable product can be summarized as follows:

In Report ER 79-9		This Report	
MINEABLE COAL	Level 1	COAL IN MINEABLE SEAMS	
RECOVERABLE COAL	Level 2	RECOVERABLE COAL	
CLEAN COAL	Level 3	CLEAN COAL	but for moisture difference and handling losses these could be synonymous
SALEABLE COAL	Level 4	SALEABLE COAL	

Definitions of the reserve terms used in this report are given in Appendix "B".

Before leaving the subject of coal reserve terminology it is worth noting that coal actually covers a wide range of commodities of different compositions, uses and values, unlike virtually any other mineral commodity. Coal spans the continuum from peat to anthracite. One tonne of saleable bituminous coal can be worth roughly five times that of one tonne of saleable sub-bituminous coal. In time, coal reserve assessments should provide answers to questions of supply for different markets, including:

- metallurgical coal market
- export thermal coal market
- mine-mouth power generating market
- chemical feedstock market, including coal conversion to gaseous and liquid hydrocarbons.

2.2 CLASSIFICATION OF COAL BY RANK, BASED ON COAL ANALYSIS

Canada uses the systems and procedures of the American Society for Testing and Materials (ASTM) for sampling, analysing and classifying coals by rank, as detailed in the Annual Book of ASTM Standards (10). Basically coals are ranked according to their degree of metamorphism, or progressive alteration, in the natural series from lignite to anthracite.

Classification in the ASTM system is a function of fixed carbon content and calorific value calculated to the mineral-matter-free basis. The higher-rank coals are classified according to fixed carbon on the dry basis whereas the lower-rank coals are classed according to calorific value on the moist basis. The agglomerating characteristics of coals (i.e. their

binding and/or swelling qualities when heated in the absence of oxygen) are used to differentiate between certain adjacent groups in the ranking. Figure 2 summarizes the ASTM classification of coal by rank and Appendix "D" provides details.

The approved abbreviations (10) of the ranks of coal by group are noted below:

ma = meta-anthracite
an = anthracite
sa = semianthracite
lvb = low volatile bituminous
mvb = medium volatile bituminous
hvAb = high volatile A bituminous
hvBb = high volatile B bituminous
hvCb = high volatile C bituminous
subA = subbituminous A
subB = subbituminous B
subC = subbituminous C
ligA = lignite A
ligB = lignite B

The proximate analysis of coal (and coke) by definition (10) is the assay of the moisture, ash and volatile matter and the calculation of fixed carbon by difference. In other words ... % fixed carbon = 100 - (% moisture + % ash + % volatile matter), with all percentages on the same moisture reference base. Other constitutents such as sulphur and phosphorus are not included with proximate analyses.

The term ultimate analysis as applied to coal (and coke) is by definition (10) the determination of carbon and hydrogen in the material, as found in the gaseous products of its complete combustion, the determination of sulphur, nitrogen, and ash in the material as a whole, and the calculation of oxygen by difference. The determination of phosphorus or chlorine is not a part of the ultimate analysis of coal. Moisture is not a part of the ultimate analysis of coal but must be determined in order that analytical data may be connected to bases other than that of the analysis sample. As some coals contain mineral carbonates, and practically all coals contain clay or shale which in turn contain combined water, a part of the carbon,

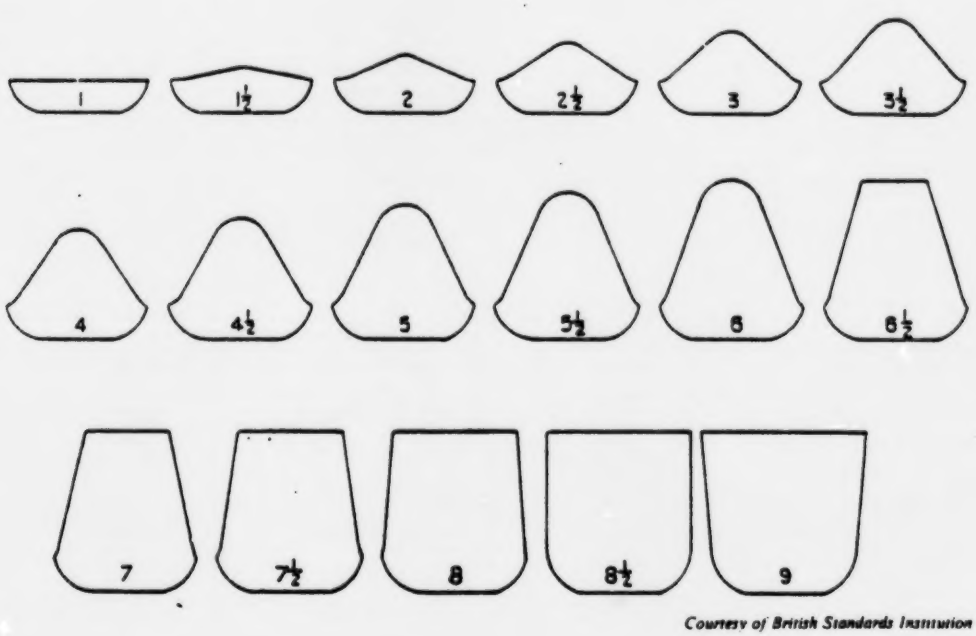
VM%*	FC%*	CLASS	GROUP	CALORIFIC VALUE **	
				Btu per lb	MJ/kg
		ANTHRACITIC (1)	META — ANTHRACITE		
2	98		ANTHRACITE		
8	92		SEMIANTHRACITE		
14	86	BITUMINOUS (2)	LOW VOLATILE BITUMINOUS		
22	78		MEDIUM VOLATILE BITUMINOUS		
31	69		HIGH VOLATILE A BITUMINOUS	14 000	32.6
			HIGH VOLATILE B BITUMINOUS	13 000	30.2
			HIGH VOLATILE C BITUMINOUS	11 500	26.7
		SUBBITUMINOUS (4)	SUBBITUMINOUS A (3)	10 500	24.4
			SUBBITUMINOUS B	9 500	22.1
			SUBBITUMINOUS C	8 300	19.3
		LIGNITIC (4)	LIGNITE A	6 300	14.7
			LIGNITE B		

* Dry, mineral-matter-free basis.
** Moist, mineral-matter-free basis.
(1) Non-agglomerating; if agglomerating classified as low volatile bituminous.
(2) Commonly agglomerating.
(3) If agglomerating classified as high volatile C bituminous.
(4) Non-agglomerating.
VM : Volatile matter
FC : Fixed carbon

Figure 2. Summarized classification of coal by rank.
(after Report ER 79-9)

hydrogen, and oxygen found in the products of combustion may arise from these mineral components.

The Free-Swelling Index (FSI) of coal is a number ranging from 1 to 9 based on a small-scale test of the free-swelling properties of coal. The results may be used as an indication of the caking characteristic of the coal when burned as a fuel, and hence is an indicator of the coals suitability for coke-making purposes. Basically, the test involves a one gram sample being heated in a covered crucible and the resulting coke button's profile being compared with the series of standard profiles shown in Fig. 3.



Courtesy of British Standards Institution

Fig. 3 - Full-scale standard profiles and corresponding Free-swelling Index (FEI) numbers, after reference (10)

2.3 CHARACTERISTICS OF COAL BY PROVINCE AND COAL REGION

All ranks of coal occur in Canada, although no anthracitic coals have been produced since the closure of the Canmore Mines in 1979. Besides this wide range in rank it is worth noting that coals of the same rank, but from different regions, can vary significantly when quality characteristics are compared. For example, much of the high volatile bituminous coal from the Sydney Coalfield in Nova Scotia is an agglomerating coal, high in sulphur and low in ash. The same rank of coal from the Coalspur Coalfield in Alberta is non-agglomerating, low in sulphur and high in ash. Appendix "E" summarizes the salient quality characteristics of coal in the major coalfields or coal regions of Canada.

Coal deposits being considered for particular uses should have certain minimal quantities of recoverable coal. For thermal coal the situation in Alberta is well-documented and serves as a guide.

In 1980, 75.2% of the electrical power in Alberta was generated by coal-burning units, with the remainder made up of gas, hydro and oil, in that order. The coal burned was virtually all of sub-bituminous rank, and totalled 10.4 million tonnes (11). It was a matter of provincial government policy (as of December, 1981) that all new power generating capacity in Alberta would come from coal-burning units. Table 3 lists power generating units either recently commissioned, under construction or approved for construction. Considering plant capital cost, plant heat rates and adaptability to integrate into the provincial electrical power grid, it has been judged that coal burning electrical generating units, each of 375 megawatts nominal capacity, are near the ideal size for Alberta. The difference between installed nominal capacity (i.e. 375 MW) and net capacity (e.g. 351 MW) represents the power needed for operating the power unit's pulverizers, fans, cooling pumps, etc.

For design purposes the quantity of sub-bituminous coal, with an average heating value similar to Wabamun coal, needed to supply each 375 MW capacity generator of the design operating at the relatively new Sundance Steam Generating Plant is 209 tonnes per hour (12). Assuming operation at full load and an 85% average annual capacity or availability factor for the generating unit, then the annual coal demand would be 0.85 x 209 x 24 x 365 = 1 556 000 tonnes. Generating units of this type have a planned life of 30 years. Accordingly, when considering subbituminous reserves of coal for

electric power generation this assessment should be done in terms of coal blocks containing 47 000 000 tonnes of recoverable coal per 375 MW capacity unit. Assuming a recovery factor of 0.85 for strip-mined coal, this 47 000 000 tonnes of recoverable coal is equivalent to 55 000 000 tonnes of coal-in-mineable seams. The heating value of 47 000 000 tonnes, assuming 18.2 MJ/kg, is 850×10^{15} joules, or 850 petajoules.

Assessing the potential of a coal deposit as a feedstock for conversion into hydrocarbon products must be done with an eye on the process technology to be utilized. These processes involve complex chemical technology. All have the same basic aim of increasing the hydrogen-to-carbon (H/C) ratio beyond that of the coal feedstock, while at the same time reducing heteroaton (sulphur, oxygen, nitrogen) content and removing mineral matter. Three recent CANMET reports give an apt description of the various routes for coal liquifaction and gasification (13,14,15). Kelly's report (15) includes a figure, reproduced here as Fig. 4, which displays the atomic H/C ratio for various feedstocks, including coal of various ranks, and the end products.

Among the main factors that bear on an individual coal deposit's amenability as a feedstock for converstion, besides the coal's inherent reactivity, are: cost of mining, availability of a certain minimum quantity of recoverable coal, proximity of a cheap and plentiful source of hydrogen (e.g. natural gas) and availability of process water. As well, the coal deposit must be viewed in terms of its value for alternate uses. It makes little economic sense to consider, for example, the large deposits of high quality coal found in the Crowsnest and Peace River Coalfields as potential feedstock.

Strip mining with large draglines, as carried out in the plains of Saskatchewan and Alberta, is currently the cheapest mining method in Canada, and a similar analogy applies to the Unites States and Australia. Estimates of coal feedstock requirements for coal conversion appear to be a matter of opinion. To realize economies of scale Taylor suggests (13) a coal liquifaction plant would need to produce 16 000 m^3/day (equivalent to 100 000 bbl/day) of liquid hydrocarbons. Assuming on optomistic yield of 0.5 m^3/t (3 bbl/tonne) of coal, such a plant would require a coal feedstock of 30 000 tonnes per day or about 11 000 000 tonnes per annum. Assuming a 20 year plant service life, this translates into a feedstock requirement

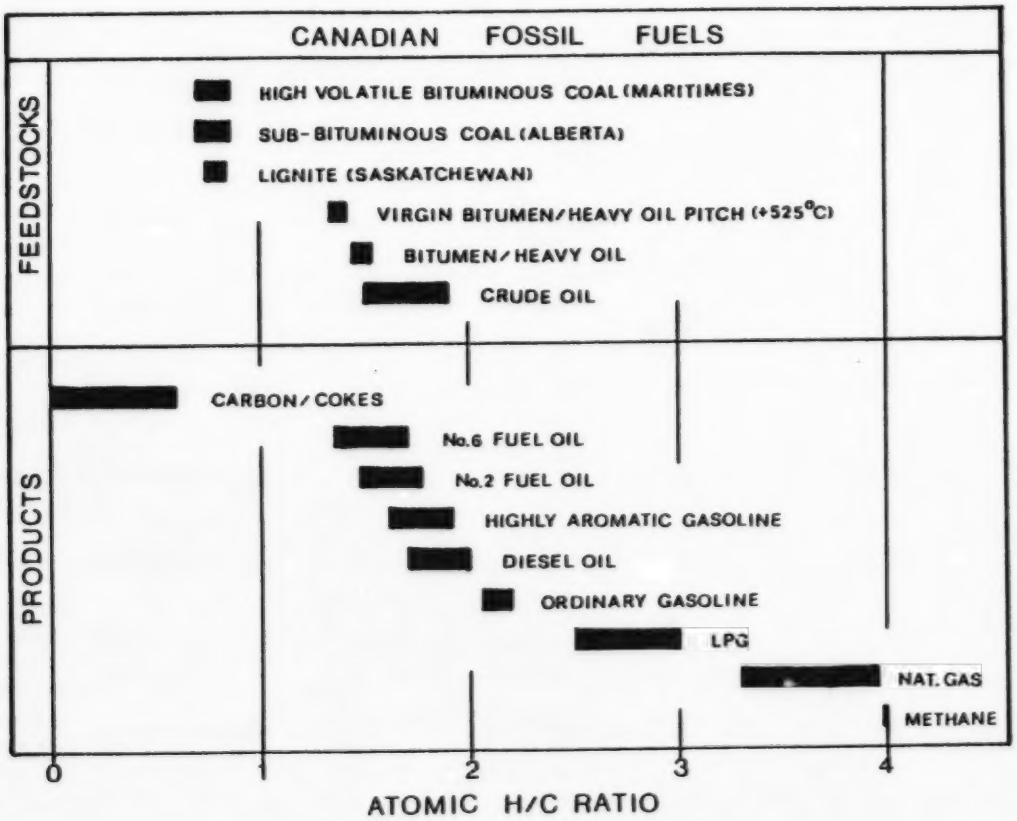


Fig. 4 - Atomic hydrogen-to-carbon ratio of Canadian fossil fuels (after Kelly (15))

Table 3 - Power generating units approved for Alberta

Commissioning year; Utility's name	Unit's name	Net capacity (MW)	Coalfield	Heating Value, MJ/kg	Coal demand Mt/year	Cumulative demand Mt
1980 Calgary Power	Sundance #6	351	Wabamun	18.236	1.5	10.4
1981 Alberta Power	Battle River #5	351	Battle River	18.132	1.6	12.0
1982 TransAlta Utilities*	Keephills #1	363	Wabamun	18.2	1.5	13.5
1983 TransAlta Utilities*	Keephills #2	363	Wabamun	18.2	1.5	15.0
1985 Alberta Power	Sheerness #1	363	Sheerness	16.5	1.7	16.7
1986 Alberta Power	Sheerness #2	363	Sheerness	16.5	1.7	18.4
Nov. 1986 Edmonton Power	Genesee #1	365	Wetaskiwin	19.5	1.5	19.9
Aug. 1987 Edmonton Power	Genesee #2	365	Wetaskiwin	19.5	1.5	21.4

*formerly Calgary Power

Table 4 - 1981 Coal reserves in Canada, in megatonnes (continued)

(for definition of reserce/reserve terminology see Appendices A and B)

Province	Coalfield	*Coal rank	Resources of immediate interest	Coal in mineable seams	Recoverable coal	Clean coal
NOVA SCOTIA	Sumberland-Springhill	hvb	2.6	0.1+	0.1+	NA
	Inverness	hvb	2.8	2.8	1.4	NA
	Pictou	hvb	0.2	0.2	0.1	NA
	Sydney	hvb	982	809	443	339
	TOTAL		987.6	812.1	444.6	339
NEW BRUNSWICK	Minto	hvb	13.8	5.8	5.7	NA
ONTARIO	Onakawana	lig	218	0	0	NA
SASKATCHEWAN	Estevan	lig	780	2 121	1 697	NA
	Willow Bunch	lig	1 791			NA
	Wood Mountain	lig	1 011			NA
	Cypress	lig	569			NA
	TOTAL		4 151	2 121	1 697	NA
ALBERTA PLAINS	Barrhead	sub	410	NA	NA	NA
	Battle River	sub	2 125	152	93	NA
	Blackfoot	sub	179	NA	NA	NA
	Bow Island	sub	34	NA	NA	NA
	Brooks	sub	192	NA	NA	NA
	Buffalo Hill	sub	630	NA	NA	NA
	Chain Lakes	sub	30	NA	NA	NA
	Comrey	sub	9	NA	NA	NA
	Cypress Hills	lig	33	NA	NA	NA
	Drumheller	sub	803	41	10	NA
	East Brooks	sub	120	NA	NA	NA
	East Edmonton	sub	996	NA	NA	NA
	Fox Creek	sub	1 267	NA	NA	NA
	Garden Plain	sub	57	NA	NA	NA

Table 4 - 1981 coal reserves in Canada, in megatonnes (continued)

Province	Coalfield	*Coal rank	Resources of immediate interest	Coal in mineable seams	Recoverable coal	Clean coal
ALBERTA PLAINS	Grassy Lake	sub	53	NA	NA	NA
	Hussar	sub	120	NA	NA	NA
	Lesser Slave Lake	lig	69	NA	NA	NA
	Lethbridge	hvb	260	NA	NA	NA
	Lucky Strike	sub	16	NA	NA	NA
	Mayerthorpe	sub	1 139	3.1	2.0	NA
	Medicine Hat	sub	247	NA	NA	NA
	Morinville	sub	977	12.7	8.3	NA
	Musreau Lake	hvb	37	NA	NA	NA
	Red Deer	sub	1 808	6.0	4.4	NA
	Rolling Hills	sub	130	NA	NA	NA
	Sheerness	sub	200	170	126	NA
	South Swan Hills	sub	527	0	0	NA
	Standard	sub	12	NA	NA	NA
	Taber	sub	12	NA	NA	NA
	Thorhild-Abee	lig	26	1.6	1.2	NA
	Tofield-Dodds	sub	1 650	1.3	1.0	NA
	Wabamun	sub	2 168	687	529	NA
	Wetaskiwin	sub	2 021	249.7	154.6	NA
	Isolated Deposits	lig-hvb	133	NA	NA	NA
	TOTAL		18 490	1 324	929	
ALBERTA FOOTHILLS	Coalspur	hvb	517	158	130	78
	Hannington	NA	216	NA	NA	NA
	McLeod River	hvb	322	NA	NA	NA
	Obed Mountain	hvb	174	145	110	68
	Turner Valley	hvb	13	NA	NA	NA
	Isolated Deposits	hvb	62	NA	NA	NA
	TOTAL		1 304	303	240	146

Table 4 - 1981 coal reserves in Canada, in megatonnes (concluded)

Province	Coalfield	*Coal rank	Resources of immediate interest	Coal in mineable seams	Recoverable coal	Clean coal
ALBERTA MOUNTAINS	Beaver Mines	hvb	11	NA	NA	NA
	Bellevue	hvb	135	NA	NA	NA
	Blairmore	mvb	476	NA	NA	NA
	Brule	lvb	51	NA	NA	NA
	Cadomin-Luscar	mvb	407	185	94	76
	Canmore	lvb	455	NA	NA	NA
	Coleman	mvb	374	NA	NA	NA
	Daisy Creek	NA	85	NA	NA	NA
	Kakwa River	lvb-hvb	101	NA	NA	NA
	Kananaskis	NA	80	NA	NA	NA
	Mountain Park	hvb	140	NA	NA	NA
	Nordegg	lvb	233	NA	NA	NA
	Oldman River	NA	353	NA	NA	NA
	Ram River	NA	379	NA	NA	NA
	Savanna Creek	NA	133	NA	NA	NA
	Smoky River	lvb	939	424	165	115
	Tent Mountain	mvb	93	NA	NA	NA
	Isolated Deposits	lvb	441	NA	NA	NA
	TOTAL		4 886	609	259	191
BRITISH COLUMBIA	Comox	hvb	30	16	15	10
	Crowsnest	lvb-mvb	605	596	472	397
	Elk Valley	lvb-hvb	8 500	1 166	1 102	735
	Flathead	lvb-mvb	132	NA	NA	NA
	Hat Creek	lig-sub	1 739	739	566	NA
	Peace River	mvb	1 760	759	509	357

*lig = lignitic; sub = subbituminous; lvb = low volatile bituminous; mvb = medium volatile bituminous; hvb = high volatile bituminous

Table 5 - 1981 coal reserves in Canada, by rank

Rank Region Coalfield	Coal in mineable seams (megatonnes)	Recoverable coal (megatonnes)	Recoverable coal heating value (petajoules)
LIGNITIC			
Saskatchewan			
All coalfields	2 121	1 697	23 800
British Columbia			
Hat Creek	739	566	6 800
Sub-total, lignitic	2 860	2 263	30 600
SUBBITUMINOUS			
Alberta			
Battle River	152	93	1 800
Drumheller	41	10	200
Morinville	12	8	100
Red Deer	6	4	100
Sheerness	170	126	2 100
Wabamun	687	529	9 800
Wetaskiwin	250	155	2 900
Others	6	4	-
Sub-total, subbituminous	1 324	929	17 000
BITUMINOUS			
Nova Scotia			
Sydney	809	443	12 000
New Brunswick			
Minto	5.8	5.7	200
Alberta			
Coalspur	158	130	2 900
Obed Mountain	145	110	2 100
Cadomin Luscar	185	94	2 400
Smoky River	424	165	4 100
British Columbia			
Comox	16	15	400
Crowsnest	596	472	11 800
Elk Valley	1 166	1 102	27 500
Peace River	759	509	12 700
Sub-total, bituminous	4 264	3 046	76 100
TOTAL, all ranks			123 700
BITUMINOUS METALLURGICAL, included in BITUMINOUS above			
Nova Scotia	243	133	
Alberta	609	259	
British Columbia	2 201	1 643	
TOTAL, metallurgical	3 053	2 035	

of 220 000 000 tonnes of recoverable coal or (using a 0.85 recovery factor) roughly 260 000 000 tonnes of coal-in-mineable seams. The rank and large quantity of recoverable coal in the Hat Creek Coalfield make this a candidate coal for conversion along with a few other deposits of subbituminous and lignite coals in the plains of Alberta and Saskatchewan.

2.4 COAL RESERVES BY PROVINCE/COAL REGION/COALFIELD

Coal reserve quantities listed in Table 4 fit the definition of coal reserves stated in Appendix "B". These quantities are part of the COAL RESOURCES OF IMMEDIATE INTEREST defined in Appendix "A", except for the resource numbers given for Alberta for reasons which are given in the next two paragraphs. Coal resources of immediate interest have been tabulated along with reserves so that readers can get a better picture of the resource base from which the reserve quantities have been derived. Only those coal resources which fall within the MEASURED and INDICATED categories have been presented. Those resources whose geological assurance of existence categorizes them as INFERRED have been excluded, in line with the definitions given in Appendices A and B, as have RESOURCES OF FUTURE INTEREST.

Alberta's coal resources and reserves are assessed by its Energy Resources Conservation Board (ERCB) and are reported annually (16). However, ERCB's criteria and procedures for defining reserves differ from those used by Energy, Mines and Resources and a direct correlation between the two systems is not possible. The RESOURCES OF IMMEDIATE INTEREST presented in Table 4 for Alberta have been selected from ERCB's Report 82-31 "Resources of Coal, Province of Alberta, at December 31, 1981". Only those resources out of which ERCB derived some reserve quantities, using the generalized mining criteria stated in its report, have been presented. No resource numbers have been included where, according to ERCB Report 82-31, deposits are considered to have no recoverable coal.

The reserve quantities given in Table 4 for Alberta are those defined by ERCB as "mine permit reserves". Developers wishing to mine coal in Alberta must first obtain a permit and license from ERCB. An application for a permit must contain extensive site-specific information on in-situ coal quantities, coal quality, proposed mining methods, marketing of coal etc. This may be considered the equivalent to an engineering feasibility study. Thus, ERCB's MINE PERMIT RESERVES fit EMR's reserve definitions.

2.5 COAL RESERVES BY RANK

Tonnage figures for British Columbia and for Canada as a whole have purposely not been totalled, because such summations would include coal of various ranks which, when lumped together, give a number with little meaning. Totals can more usefully be expressed in terms of heating value, as shown in Table 5. Coal deposits with less than 2 megatonnes recoverable coal have been excluded from this table.

2.6 COAL RESERVES BY LIKELY MINING METHOD

The mining methods identified for individual coal deposits in engineering feasibility studies are presented in Table 6. The two surface mining methods refer to the basic way overburden is stripped from the coal, and not to how coal is excavated.

2.7 RESERVES TIED UP BY LAND USE RESTRICTIONS IN WESTERN CANADA

Only the Province of Alberta has classified its land area into categories with respect to coal exploration and development. In British Columbia and Saskatchewan new coal projects are reviewed on an individual basis, as they also are in Alberta, with acceptable environmental impact assessments as being an essential part of the approval procedure.

Alberta's coal development policy is described in Report ERCB 82-31 from which the following is quoted:

"The Alberta Coal Development Policy, released in 1976, divides Alberta into three regions:

- the Settled Region
- the Northern Forested Region
- the Eastern Slopes Region

"Within these regions, provincial lands are classified into four categories with respect to coal exploration and development. In summary, the allowable activity in these categories is as follows:

Table 6 - 1981 coal reserves in Canada, by likely mining method (in megatonnes)

Rank Province Coalfield	Recoverable coal	Surface methods		Underground methods		
		shovel/truck	dragline	longwall	room & pillar	hydraulic
LIGNITIC						
Saskatchewan						
All coalfields	1 697		1 697			
British Columbia						
Hat Creek	566	566				
Sub-total, lignitic	2 263	566	1 697			
SUBBITUMINOUS						
Alberta						
Battle River	93		93			
Drumheller	10			10		
Sheerness	126		126			
Wabamun	529		529			
Wetaskiwin	155		155			
Others	16	16				
Sub-total, subbituminous	929	16	903	10		
BITUMINOUS						
Nova Scotia						
Cumberland-Springhill	0.1	0.1				
Inverness	1.4				1.4	
Pictou	0.1				0.1	
Sydney	443			443		
New Brunswick						
Minto	5.7		5.7			
Alberta						
Coalspur	130	87	24	18	1	
Obed Mountain	110	35	75			
Cadomin-Luscar	94	75			9	10
Smoky River	165	96			69	
British Columbia						
Comox	15	6	9			
Crowsnest	472	402			2	68
Elk Valley	1 102	1 089	13			
Peace River	509	423			86	
Sub-total, bituminous	3 047	2 213	127	461	168	78
TOTAL, by mining method		2 795	2 727	471	168	78

Category	Exploration	Development
1	None	None
2	Limited exploration permitted under strict control	Restricted development, underground or in-situ only
3	Exploration permitted under normal approval procedures	Restricted development
4	Exploration permitted under normal approval procedures	Development permitted under normal approval procedures

"The Settled Region includes some Category 1 areas, but falls mainly in Category 4.

"The Northern Forested Region includes some Category 1 areas, but mostly comprises Category 3.

"The Eastern Slopes Region includes areas in Categories 1, 2 and 3, and some in Category 4."

As mentioned previously Alberta's definitions for coal resources and reserves differ from those adopted by EMR. Table 7 is taken from Report ERCB 82-31 and is presented so that readers can get an appreciation of coal quantities tied up by land use restrictions in Alberta. Column 6 shows the quantities of coal that would normally be classified by Alberta as "recoverable", but are not available for exploitation under the policy.

Table 7 - Coal in Alberta sterilized by land use restrictions

Category	1	2	3	4	5	6
	Established resources (gigatonnes)					
	Surface		Underground		Reserves	Reserves
	In place	Reserves	In place	Reserves	available	sterilized
MOUNTAIN REGION						
1	0.14	-	2.3	-	-	0.75
2	0.36	-	2.0	0.58	0.58	0.32
3	-	-	-	-	-	-
4	0.61	0.52	2.6	0.64	1.2	-
FOOTHILLS REGION						
1	0.009	-	0.028	-	-	0.017
2	0.005	-	0.024	0.010	0.010	0.004
3	-	-	0.002	-	-	-
4	0.87	0.64	0.64	0.21	0.85	-
PLAINS REGION						
3	2.2	1.3	1.6	0.22	1.6	-
4	10	5.7	24	5.8	11	-

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APPENDIX A - DEFINITION OF MEASURED AND INDICATED COAL RESOURCES

The definition for coal whose assurance of existence is described by the terms MEASURED and INDICATED varies from region to region, according to topographical and geological conditions. The following is part of the resource classification system used by the Geological Survey of Canada and presented in Report ER 79-9 (2).

Measured Resources are resources for which tonnages are computed from information revealed in outcrops, trenches, mine workings and boreholes. The spacing of points of observation necessary to justify confidence in the character and continuity of coal seams differs from region to region according to the character of the deposits and the geological conditions. In general the points of observation should be separated by less than the following distances:

Coal regions in Canada	Maximum distance between points of observation (in metres)
Cordillera (150 m in severely contorted areas)	300
Plains	
Alberta	800
Saskatchewan	800
New Brunswick	400
Nova Scotia	
Sydney Coalfield, offshore	
Harbour and Phalen seams	1 600
Other seams	800
Sydney Coalfield, onshore	800
Other coalfields	300

Indicated Resources are resources for which tonnages are computed partly from specific measurements and partly from reasonable geological projections. For the general coal regions in Canada, the points of observation should be separated by less than the following distances:

Coal regions in Canada	Maximum distance between points of observation (in metres)
Cordillera (300 m in severely contorted areas)	600
Plains	
Alberta	1 600
Saskatchewan	1 600
New Brunswick	800
Nova Scotia	
Sydney Coalfield, offshore	
Harbour and Phalen seams	4 800
Other seams	1 600
Sydney Coalfield, onshore	1 600
Other coalfields	600

Note 1: Cordillera region includes all British Columbia and the Foothills and Mountain regions of Alberta.

Note 2: This CANMET report is not concerned with coal categorized as "inferred" or "speculative" as such coal is not within the coal supply picture which this report is attempting to portray. For the same reason this report is not concerned with "resources of future interest".

APPENDIX B - DEFINITION OF COAL RESERVES

The terminology used in this report is similar to that given in Report ER 79-9, excepting that "mineable coal" has been replaced by the term COAL IN MINEABLE SEAMS.

COAL IN MINEABLE SEAMS is that part of measured and indicated resources of immediate interest that can be considered for mining using current technology and economics, before there is any allowance for mining losses. To qualify as COAL IN MINEABLE SEAMS the following conditions must apply:

- that feasibility studies have been done, specific plans for mining method and processing (if needed) have been adopted and the overall economic feasibility for developing the coal deposit appears favourable.
- that the necessary infrastructure (townsite, power and transportation facilities) is either in place or can be amortized through coal sales.
- that the coal is legally accessible for excavation i.e. the development considered is beyond the prospectus or initial disclosure stage in the regulatory process and has received approval-in-principle from the provincial government concerned with controlling development.
- that all coal being considered for development is likely to be marketable at minimum acceptable profit levels.

RECOVERABLE COAL is that part of COAL IN MINEABLE SEAMS that would be recoverable as run-of-mine or raw coal, making allowances for mining losses. For example, in surface mining, a portion of the top of a seam will likely be lost with overburden in the stripping operation, or a part of the seam next to the spoil pile will not likely be excavated. In underground operations the most common mining loss is associated with pillars left as supports or barriers.

CLEAN COAL is that part of RECOVERABLE COAL that remains as the prime saleable product after upgrading in a preparation plant.

SALEABLE COAL is coal that meets saleable specifications; it may be clean coal with acceptable moisture content or raw coal that is ready to be used without further upgrading.

APPENDIX C - OPERATING COAL MINES AND MINES UNDER DEVELOPMENT AS OF DECEMBER 31, 1981

(Part I: Operating Coal Mines; Part II: Coal Projects in the Construction-Development Stage: Part III: Coal Projects in the Planning-Development Stage)

Part I: Operating Coal Mines (continued)

Coalfield/Mine	Owner/Operator	Mining Method	Coal Rank & Seam(s)	Recent Annual Raw Coal Production, Tonnes
NOVA SCOTIA				
Sydney Coalfield				
Lingan Mine	Cape Breton Development Corp. (CBDC)	Advancing longwall Some room-and-pillar	High-volatile A bituminous Harbour Seam; 1-3% sulphur	1,800,000 t.p.y. metallurgical & thermal
No. 26 Colliery	CBDC	Advancing longwall	High-volatile A bituminous Harbour Seam; 1-2% sulphur	1,100,000 t.p.y. metallurgical & thermal
Prince	CBDC	Retreating longwall (short-faces); room-and-pillar (development)	High-volatile A bituminous Hub Seam; 3-5% sulphur	250,000 t.p.y. thermal
Pit at Pt. Aconi	Thomas Brogan & Son	Strip mining	High-volatile A bituminous Bonar Seam; 3-6% sulphur	75,000 t.p.y. thermal
Pit at Pt. Aconi	NOVACO	Dragline stripping	High-volatile A bituminous Sydney Main Seam; 3-5% sulphur	200,000 t.p.y. thermal
SELMINCO	Discard dump reclamation at Sydney Mines	Loader/trucks	High-volatile A bituminous	60,000 t.p.y. thermal
Inverness Coalfield				
St. Rose Mine	Evans Coal Mines Ltd.	Room-and-pillar	High-volatile B bituminous No. 5 Seam; 4-5% sulphur	45,000 t.p.y. thermal

Part I: Operating Coal Mines (continued)

Coalfield/Mine	Owner/Operator	Mining Method	Coal Rank & Seam(s)	Recent Annual Raw Coal Production, Tonnes
Pictou Coalfield				
Drummond Westville Mine	Drummond Coal Co. Ltd.	Room-and-pillar	High-volatile A bituminous Scott Seam; 1-2% sulphur	20,000 t.p.y. thermal
Discard dump reclamation	Thorburn Mining Ltd.	Loader/trucks	High-volatile A bituminous 1-4% sulphur	30,000 t.p.y. thermal
NEW BRUNSWICK				
Minto Coalfield				
Minto/Chipman Area Pits	New Brunswick Coal Co.	Dragline strip mining	High-volatile A bituminous Single thin seam; 6.5-8% sulphur	500,000 t.p.y. thermal
SASKATCHEWAN				
Estevan Coalfield				
Bienfait Mine	Bienfait Coal Co. Ltd. (Luscar Ltd. subsidiary)	Dragline strip mining	Lignite A; single seam in the Estevan Zone; 0.4-0.6% sulphur	500,000 t.p.y. thermal
Boundary Dam Mine	Manitoba and Saskatchewan Coal Co. Ltd. (Luscar Ltd. subsidiary)	Dragline strip mining	Lignite A; 2 seams in the Estevan Zone; 0.4-0.6% sulphur	1,850,000 t.p.y. thermal
Klimax Mine	Manalta Coal Ltd.	Dragline strip mining	Lignite A; single seam Estevan Zone; 0.4-0.6% sulphur	720,000 t.p.y. thermal
Souris Valley Mine	Saskatchewan Power Corp.	Dragline strip mining	Lignite A; two seams in the Estevan Zone; 0.4-0.6% sulphur	350,000 t.p.y. thermal
Utility Mine	Saskatchewan Power Corp. (Manalta Coal Ltd. operator)	Dragline strip mining	Lignite A; one seam in the Estevan Zone; 0.4-0.6% sulphur	2,400,000 t.p.y. thermal

Part I: Operating Coal Mines (continued)

Coalfield/Mine	Owner/Operator	Mining Method	Coal Rank & Seam(s)	Recent Annual Raw Coal Production, Tonnes
Willow Bunch Coalfield				
Poplar River Mine	Saskatchewan Power Corp.	Dragline strip mining	Lignite A; one seam in the Hart Zone; 0.5% sulphur	1,800,000 t.p.y. thermal
ALBERTA'S PLAINS REGION				
Battle River Coalfield				
Diplomat Mine (No. 1578)	Forestburg Collieries Ltd. (Luscar Ltd. subsidiary)	Dragline strip mining	Subbituminous C; Battle River Seam; 0.4% sulphur	1,000,000 t.p.y.; thermal Paintearth Mine just beginning coal production
Paintearth Mine (No. 1781)	Forestburg Collieries Ltd. (Luscar Ltd. subsidiary)	Shovel/dragline strip mining	Subbituminous C; Paintearth Seam; 0.4% sulphur	
Vesta Mine (No. 1046)	Alberta Power Ltd. (Manalta Coal Ltd. operator)	Dragline strip mining	Subbituminous C; Single seam; 0.4% sulphur	1,100,000 t.p.y. thermal
Sheerness Coalfield				
Roselyn Mine (No. 443)	Manalta Coal Ltd.	Dragline strip mining	Subbituminous C; Single seam; 0.4% sulphur	70,000 t.p.y.; thermal (capacity 400,000 t.p.y.)
Wabamun Coalfield				
Highvale Mine (No. 1769)	Transalta Utilities Ltd. (Manalta Coal Ltd. operator)	Dragline strip mining	Subbituminous B; up to five seams; 0.3% sulphur	8,000,000 t.p.y. thermal
Whitewood Mine (No. 1757)	Transalta Utilities Ltd. (Manalta Coal Ltd. operator)	Dragline strip mining	Subbituminous B; up to five seams; 0.3% sulphur	1,500,000 t.p.y. thermal

Part I: Operating Coal Mines (continued)

Coalfield/Mine	Owner/Operator	Mining Method	Coal Rank & Seam(s)	Recent Annual Raw Coal Production, Tonnes
Tofield-Dodds Coalfield				
No. 215 Mine	Dodds Coal Mining Co. Ltd.		Subbituminous C	60,000 t.p.y. thermal
Morinville Coalfield				
No. 1582 Mine	Egg Lake Coal Co. Ltd.		Subbituminous C	
Thorhild-Abee Coalfield				
No. 1562 Mine	North Point Coal Co. Ltd.		Lignite A	
Red Deer Coalfield				
No. 809 Mine	Sissons Mine Ltd.		Subbituminous A/B	
Wetaskiwin Coalfield				
No. 1670 Mine	Warburg Coal Co. Ltd.		Subbituminous A/B	
ALBERTA'S FOOTHILLS REGION				
Coalspur Coalfield				
Coal Valley Mine (No. 1778)	Luscar Sterco (1977) Ltd. (75% Luscar Ltd. 25% Alberta Energy Co. Ltd.)	Shovel-truck and dragline stripping	High-volatile C/B bituminous; Val D'Or/ Mynheer Seams; 0.3% sulphur	5,000,000 t.p.y. thermal
ALBERTA'S MOUNTAIN REGION				
Cadomin-Luscar Coalfield				
Luscar Mine (No. 1768)	Cardinal River Coals Ltd. (50% Luscar Ltd. 50% Consolidation Coal Co. of Canada)	Shovel-truck stripping	Medium-volatile bituminous Jewel Seam; 0.3% sulphur	1,500,000 t.p.y. metallurgical (capacity 3,000,000 t.p.y.)

Part I: Operating Coal Mines (concluded)

Coalfield/Mine	Owner/Operator	Mining Method	Coal Rank & Seam(s)	Recent Annual Raw Coal Production, Tonnes
Smoky River Coalfield				
No. 1774 Mine	McIntyre Mines Ltd.	Shovel-truck stripping	Low-volatile bituminous Seams No. 4, 10, 11; 0.4-0.5% sulphur	2,200,000 t.p.y. metallurgical and some thermal
No. 1765 Mine	McIntyre Mines Ltd.	Room-and-Pillar	Low-volatile bituminous Seams No. 4, 11; 0.4-0.5% sulphur	1,000,000 t.p.y. metallurgical
Coleman/Tent Mountain Coalfield				
Discard dump reclamation	Coleman Collieries Ltd.	Loader/trucks	Medium-volatile bituminous various seams	300,000 t.p.y. processed thermal
BRITISH COLUMBIA				
Crowsnest Coalfield				
Harmer Surface Mine	B.C. Coal Ltd.	Shovel-truck stripping	Low-volatile bituminous 10 Seam and 8 Seam; 0.3-0.4% sulphur	7,000,000 t.p.y. metallurgical and some thermal
Michel Underground Mine	B.C. Coal Ltd.	Hydraulic; some room-and-pillar	Low-volatile bituminous 10 Seam; 0.3-0.5% sulphur	700,000 t.p.y. (hydraulic) plus 150,000 t.p.y. (room-and-pillar); metallurgical coal
Corbin Mine	Byron Creek Collieries Ltd. (Esso Minerals Canada subsidiary)	Loader/trucks	Medium-volatile bituminous Mammoth Seam; 0.2-0.3% sulphur	1,000,000 t.p.y. thermal
Elk Valley Coalfield				
Fording River Mine	Fording Coal Ltd.	Shovel-truck stripping and dragline stripping	Low, medium & high volatile bituminous; multi-seams; 0.3-0.5% sulphur	5,600,000 t.p.y.

Part II: Coal Projects in the Construction-Development Stage (continued)

Coalfield/Project	Owner/Operator	Mining Method	Coal Rank & Seam(s)	Projected Annual Raw Coal Production, Tonnes
NOVA SCOTIA				
Sydney Coalfield				
Donkin-Morien Project	DEVCO	Advancing longwall	High-volatile A bituminous Harbour Seam; 1-3% sulphur	Projected output of 3,000,000 t.p.y. of thermal coal by 1987
Lingan-Phalen Project	DEVCO	Advancing longwall	High-volatile A bituminous Phalen Seam; 1-3% sulphur	Projected output of 2,000,000 t.p.y. of thermal coal and metallurgical coal by 1987
Cumberland-Springhill Coalfield				
Springhill Project	NOVACO	Dragline stripping	High-volatile A bituminous Rodney Seam; 1-4% sulphur	Projected output of 100,000 t.p.y. of thermal coal by 1983.
ALBERTA'S FOOTHILLS REGION				
Coalspur Coalfield				
Silkstone Project (No. 1796)	Luscar Sterco (1977) Ltd. (75% Luscar Ltd. 25% Alberta Energy Co. Ltd.)	Room-and-pillar	High-volatile C bituminous Upper and Lower Silkstone Seams	700,000 t.p.y. thermal; 1983
ALBERTA'S MOUNTAIN REGION				
Cadomin-Luscar Coalfield				
Gregg River Project (No. 1770)	Gregg River Resources Ltd. (Manalta Coal Ltd. and others)	Shovel-truck stripping	Medium-volatile bituminous Jewel Seam; 0.3% sulphur	2,700,000 t.p.y. metallurgical and some thermal; 1983
Hydraulic Mine Project (No. 1792)	Cardinal River Coals Ltd. (50% Luscar Ltd. 50% Consolidation Coal Co. of Canada)	Hydraulic mining	Medium-volatile bituminous Jewel Seam; 0.3% sulphur	1,300,000 t.p.y. metallurgical; 1984

Part II: Coal Projects in the Construction-Development Stage (concluded)

Coalfield/Project	Owner/Operator	Mining Method	Coal Rank & Seam(s)	Projected Annual Raw Coal Producation, Tonnes
BRITISH COLUMBIA				
Elk Valley Coalfield				
Greenhills Project	B.C. Coal Ltd./Pohang Iron and Steel Co. Ltd.	Shovel-truck stripping	Medium and high-volatile A bituminous; Seams 1, 7, 10, 16 and others; 0.3-0.5% sulphur	2,100,000 t.p.y. metallurgical and some thermal; 1983
Line Creek Project	Crowsnest Resources Ltd. (Shell Canada Resources Ltd. subsidiary)	Shovel-truck stripping	Low-and medium-volatile bituminous; Seams 8, 9, 10B, 10A and others; 0.3-0.5% sulphur	2,500,000 t.p.y. metallurgical and thermal; 1983
Peace River Coalfield				
Bullmoose Project	Teck Corporation/Amalgamated Brameda-Yukon Ltd.	Shovel-truck stripping	Medium-volatile bituminous; five seams; 0.3-0.5% sulphur	2,200,000 t.p.y. metallurgical; 1983-84
Quintette Project	Denison Mines Ltd. and partners	Shovel-truck stripping; some dragline stripping	Medium-volatile bituminous; multi-seams; 0.3-0.5% sulphur	7,000,000 t.p.y. of metallurgical and 1,250,000 t.p.y. of thermal; 1983-84

*** Part III: Coal Projects in the Planning-Development Stage (continued)

Coalfield/Project	Owner/Operator	Mining Method	Coal Rank & Seam(s)	Remarks
ALBERTA'S PLAINS REGION				
Lethbridge Coalfield				
Kipp Project (No. 1787E)	Petro-Canada	Room-and-Pillar or Shortwall/longwall	High-volatile C bituminous; Galt Seam; 0.6% sulphur approx.	Thermal coal
Shaughnessy Project	Fording Coal Ltd.	Room-and-Pillar or Longwall/shortwall	High-volatile C bituminous; Galt Seam; 0.6% sulphur approx.	Thermal coal
Sheerness Coalfield				
Sheerness Project (No. 1782)	Forestburg Collieries Ltd. (Luscar Ltd. subsidiary) and Manalta Coal Ltd.	Dragline stripping	Subbituminous C; one main seam with splits and some from an upper seam; 0.4% sulphur	Projected output of 3,300,000 t.p.y. of thermal coal in 1986
South Swan Hills Coalfield				
Judy Creek Project (No. 1783E)	Esso Minerals Canada	Dragline stripping	Subbituminous C; Seams 3, 5, 7 and others; 0.3% sulphur	Thermal coal
Wetaskiwin Coalfield				
Genesee Project (No. 1785)	Edmonton Power (Fording Coal Ltd. operator)	Dragline stripping	Subbituminous A and B; Upper Main and Lower Main Seams; 0.3-0.4% sulphur	Projected output of 3,000,000 t.p.y. of thermal coal starting in 1986 and reaching capacity in 1987

*** Part III: Coal Projects in the Planning-Development Stage (continued)

Coalfield/Project	Owner/Operator	Mining Method	Coal Rank & Seam(s)	Remarks
ALBERTA'S FOOTHILLS REGION				
Obed Marsh Coalfield				
Obed Marsh Project (No. 1791)	Union Oil Co. of Canada Ltd.	Dragline stripping	High-volatile C bituminous; Seams No. 1, 2 and others; 0.5% sulphur	4,900,000 t.p.y. raw coal production capacity to produce 3,000,000 tonnes saleable thermal coal; permit granted by ERCB for mine site development
BRITISH COLUMBIA				
Comox Coalfield				
Quinsam Project	Brinco/Weldwood of Canada Ltd.	Dragline, as well as shovel-truck stripping	High-volatile A bituminous; Seams No. 1 and 2, some Seam No. 3; 1.1% sulphur	Thermal; (addendum to Stage II report in preparation)
Elk Valley Coalfield				
Elk River Project	Elco Mining Ltd. (a consortium) plus other partners	Shovel-truck stripping	Low, medium and high volatile bituminous; multiple seams; 0.6% sulphur	Metallurgical and thermal (Stage II report approved Feb/79)
Flathead Coalfield				
Sage Creek Project	Rio Algom Ltd./Pan Ocean Ltd.	Shovel-truck stripping	Low- to medium-volatile bituminous; Seams 2, 4 Upper, 4 Lower and 5; 0.5% sulphur	Metallurgical and thermal (Stage II report in preparation)
Hat Creek Coalfield				
Hat Creek Project	B.C. Hydro and Power Authority	Shovel-truck stripping	Lignite to subbitimunous; four coal zones; 0.3-0.5% sulphur	Thermal: (Stage II report under review)

*** Part III: Coal Projects in the Planning-Development Stage (concluded)

Coalfield/Project	Owner/Operator	Mining Method	Coal Rank & Seam(s)	Remarks
Peace River Coalfield				
Burnt River Project	Teck Corporation	Shovel-truck stripping	Semi-anthracite; from three to six seams; 0.3-0.5% sulphur	Thermal; (Stage II report in preparation)
Carbon Creek Project	Utah Mines Ltd.	Longwall; also shovel-truck stripping	Medium-volatile bituminous; multiple seams; 0.8% sulphur	Thermal; (Stage II report in preparation)
Monkman Project	Petro-Canada and others	Shovel-truck stripping	Medium-volatile bituminous; Seams B1, B3, B4, B9 and others; 0.4-0.5% sulphur	Thermal and some metallurgical
Sukunka Project	B.P. Canada Ltd.	Room-and-pillar, in decending multi-seam extraction	Medium-volatile bituminous; Bird Seam, Upper and Lower Chamberlain Seams	Metallurgical coal; (Stage II report approved March/81)

Note: *** Projects assigned to Part III: Coal Projects in the Planning-Development Stage are those in Alberta which have either received approval-in-principle as set forth in preliminary disclosure, or have received approvals for test pits. In British Columbia approval-in-principle is considered to be the approved Stage II submission. Those projects with either Stage II approvals or with work underway for Stage II submissions have been included.

The assessment procedure for new coal projects in Alberta and British Columbia is detailed in references (6) and (7) respectively.

APPENDIX D - Classification of Coals by Rank (ASTM)
(after Report ER 79-9)

Basis of Classification (Figure 2)

The rank classification outlined in Figure 2 is based on volatile matter, fixed carbon and heating value in Btu per pound. The higher-rank coals are classified according to fixed carbon on a dry, mineral-matter-free basis; the lower-rank coals are classified according to heating value on a moist, mineral-matter-free basis. Agglomerating character is used to differentiate between certain adjacent groups.

Classify coals having calorific values of 14 000 Btu/lb (32.6 MJ/kg) or more on the moist, mineral-matter-free basis and coals having fixed carbon of 69 per cent or more on the dry, mineral-matter-free basis, according to fixed carbon on the dry, mineral-matter-free basis; classify coals having calorific values less than 14 000 Btu/lb (32.6 MJ/kg) on the moist-mineral-matter-free basis according to calorific value on the moist, mineral-matter-free basis, provided the fixed carbon on the dry, mineral-matter-free basis is less than 69 per cent.

I Anthracitic Class — Nonagglomerating

Meta-anthracite (ma) - fixed carbon greater than or equal to 98 per cent; volatile matter equal or less than 2 per cent.

Anthracite (an) - fixed carbon less than 98 per cent and greater than or equal to 92 per cent; volatile matter greater than 2 per cent and equal or less than 8 per cent.

Semianthracite (sa) - fixed carbon less than 92 per cent, and greater than or equal to 86 per cent; volatile matter greater than 8 per cent and equal or less than 14 per cent; if agglomerating classify as low volatile.

II Bituminous Class — Commonly Agglomerating

Low volatile bituminous (lvb) - fixed carbon less than 86 per cent, and greater than or equal to 78 per cent; volatile matter greater than 14 per cent and equal or less than 22 per cent.

Medium volatile bituminous (mvb) - fixed carbon less than 78 per cent, and greater than or equal to 69 per cent; volatile matter greater than 22 per cent and equal or less than 31 per cent.

High volatile A bituminous (hvAb) - fixed carbon less than 69 per cent; volatile matter greater than 31 per cent; heating value greater than or equal to 14 000 Btu per pound (32.6 MJ/kg).

High volatile B bituminous (hvBb) - heating value less than 14 000 Btu per pound (32.6 MJ/kg), and greater than or equal to 13 000 Btu per pound (30.2 MJ/kg).

High volatile C bituminous (hvCb) - heating value less than 13 000 Btu per pound (30.2 MJ/kg), and greater than or equal to 11 500 Btu per pound (26.7 MJ/kg).

III Subbituminous Class — Nonagglomerating

Subbituminous A (subA) - heating value less than 11 500 Btu per pound (26.7 MJ/kg), and greater than or equal to 10 500 Btu per pound (24.4 MJ/kg); if agglomerating classify as high volatile C bituminous.

Subbituminous B (subB) - heating value less than 10 500 Btu per pound (24.4 MJ/kg), and greater than or equal to 9 500 Btu per pound (22.1 MJ/kg).

Subbituminous C (subC) - heating value less than 9 500 Btu per pound (22.1 MJ/kg), and greater than 8 300 Btu per pound (19.3 MJ/kg).

IV Lignitic Class — Nonagglomerating

Lignite A (ligA) - heating value less than 8 300 Btu per pound (19.3 MJ/kg), and greater than or equal to 6 300 Btu per pound (14.7 MJ/kg).

Lignite B (ligB) - heating value less than 6 300 Btu per pound (14.7 MJ/kg).

APPENDIX E - QUALITY CHARACTERISTICS OF COAL IN CANADA, BY REGION AND COALFIELD

Region/Coalfield	Rank	Current use (potential use)	Proximate analysis % (1 run-of-mine coal, 2 clean coal)					Sulphur %	Heating value (moist basis) MJ/kg	Remarks
				M	A	VM	FC			
NOVA SCOTIA										
Sydney Coalfield	hvb	70% thermal 30% metallurgical	1 2	5-8 2-8	10-18 3-12	29-32 29-35	45-55 54-62	1-4 1-2.5	24-31 29-34	low ash, variable sulphur, high reactivity
NEW BRUNSWICK										
Minto Coalfield	hvb	thermal	1	1-3	15-20	31-34	47-50	6-8		high sulphur, high ash
SASKATCHEWAN										
Estevan Coalfield	lig	thermal	1	28-35	8-15	26-31	29-34	0.4-0.6	14-17	
Willow Bunch Coalfield	lig	thermal	1	36-40	10-13	23-24	26-27	0.5	12-13	high moisture
ALBERTA PLAINS										
Battle River Coalfield	sub	thermal	1	23-25	6-12	30-35	36-38	0.3-0.4	18-20	
Lethbridge Coalfield	sub-hvb	(thermal)	1	9.5	10-20	35.5	36-44	0.5-0.6	21-24	
Sheerness Coalfield	sub	thermal	1	24-27	11-18	25-28	33-37	0.4-0.5	17-18	variable quality
South Swan Hills Coalfield	sub	(thermal, chemical feedstock)	1	22-24	21-22	24-26	30-31	0.3	15-16	
Wabamun Coalfield	sub	thermal	1	20-22	15-17	26-27	35-38	0.2-0.3	17.5-19.5	
Wetaskiwin Coalfield	sub	(thermal)	1	18-20	13-16	27-28	36-38	0.3-0.4	19-20	
ALBERTA FOOTHILLS										
Coalspur Coalfield	hvb	thermal	1	11	24-25	28	37	0.4-0.5	21	variable quality; clay bands in coal demand selective mining
			2	8.5-9.5	8-10	33	49	0.3	26	
Obed Marsh Coalfield	hvb	(thermal, chemical feedstock)	1	16-20	30-31	33	20	0.5	19	
			2	7-8	12-13	36	44	0.5	20	

Region/Coalfield	Rank	Current use (potential use)	Proximate analysis Σ 1 run-of-mine coal 2 clean coal					Sulphur Σ	Heating value (moist basis) MJ/kg	Remarks
				M	A	VM	FC			
ALBERTA MOUNTAINS										
Cadomin Luscar Coalfield	mvb	metallurgical (thermal)	1 2	5 8	12-20 10	18-20 22-24	55-65 58-60	0.3	30-31	
Smoky River Coalfield	lvb	metallurgical and some thermal	1 2	4 6	17-20 7	16 18	60-63 65-69	0.4 0.4	28 34	
BRITISH COLUMBIA										
Comox Coalfield	hvb	(thermal)	1 2	6 6-7	15.8 NA	32.7 NA	45.5 NA	1.1 NA	26	composite from 3 seams in Quinsam Project
Crowsnest Coalfield	lvb-mvb	metallurgical and thermal	1 2	4-5 8	15-20 9-10	19-23 21-22	55-60 59-61	0.3-0.4 0.3-0.4	30-31 31-33	clean thermal coal has higher ash and lower heating value
Elk Valley Coalfield	lvb-mvb -hvb	metallurigcal and some thermal	1 2	3-5 8	20-35 6.5-10	19-33 21-34	40-60 50-64	0.3-0.5 0.3-0.5	20-25 30-37	several blends of clean coal are produced
Flathead Coalfield	mvb	(thermal, metallurgical)	1 2	3-6 NA	25-35 NA	22 NA	40-50 NA	0.5 NA	20-25	Σ VM is an average value
Hat Creek Coalfield	lig-sub	(thermal, chemical feedstock)	1	23	32	24	21	0.4	11.6	values shown are averages for a highly variable coal
Peace River Corlfield	mvb	(metallurgical and thermal)	1 2 2	6 6-8 8	20-30 6-9 16	21-27 22-24 20	45-55 63-66 56	0.3-0.5 0.3-0.5 0.3-0.5	21-26 33-36 28-30	 clean metallurigcal coal clean thermal coal

Abbreviations used for rank: lig = lignitic; sub = subbituminous; hvb = high volatile bituminous; mvb = medium volatile bituminous; lvb = low volatile bituminous

Abbreviations used for proximate analysis: M = moisture; A = ash; VM = volatile matter; FC = fixed carbon